

**Submission of Replacement Formal Drawings**

Replacement drawing sheets are submitted herewith for drawing sheets 1, 5 and 7, in order to delete reference character 8 (as well as its lead line) from each of Figs. 1A, 10 and 13.

Approval and entry of these replacement drawing sheets are respectfully requested.

## REMARKS

By this amendment, claims 1-13 have been cancelled, and claims 14-30 have been added. Thus, claims 14-30 are now active in the application. Reexamination and reconsideration of the application are respectfully requested.

The specification and abstract have been carefully reviewed and revised to make grammatical and idiomatic improvements in order to aid the Examiner in further consideration of the application. The amendments to the specification and abstract are incorporated in the attached substitute specification and abstract. No new matter has been added.

Attached hereto is a marked-up version of the changes made to the specification and Abstract by the current amendment. The attachment is captioned "Version with markings to show changes made."

In items 1 and 2 on pages 2 and 3 of the Office Action, the drawings were objected to because reference characters 8 and 9 were both "used to designate 'curved portions of the sound opening'", and reference character 8 was "used to designate both 'the line of the opening' and ' the curved portion of the opening'". In order to obviate these objections, replacement drawing sheets are submitted herewith for drawing sheets 1, 5 and 7, in order to delete reference character 8 (as well as its lead line) from each of Figs. 1A, 10 and 13. Reference character 8 has also been removed from the specification.

In items 3-6 on page 3 of the Office Action, claims 1-13 were rejected under 35 U.S.C. 112, second paragraph, as being indefinite for recitation of "the sound opening includes a line." As the Examiner correctly indicated, the word "includes" implies that the "line" is within the opening. This reference was to an imaginary line that could be drawn within the opening. In order to clarify this matter, the claims now recite that the sound opening "includes an opening portion that is disposed so as to oppose a region of said diaphragm between said fixing portion and said diaphragm edge portion thereof." Corresponding corrections have been made in the specification. Accordingly, it is submitted that the rejection under 35 U.S.C. 112, second paragraph, is no longer applicable.

In items 7-14 on pages 4-9 of the Office Action, claims 1-4 were rejected under 35 U.S.C. 102(b) as being anticipated by Grasso (U.S. 5,619,585); claims 1, 8, 9, 11 and 12 were rejected under 35 U.S.C. 102(b) as being anticipated by Koike (U.S. 4,670,868); claims 5-7 were rejected under 35 U.S.C. 103(a) as being unpatentable over Grasso in view of Moner, Jr. et al. (U.S. 5,565,659); and claims 10 and 13 were rejected under 35 U.S.C. 103(a) as being unpatentable over Koike. These rejections are believed moot in view of the cancellation of claims 1-13. Furthermore, it is respectfully submitted that these rejections are clearly inapplicable to the new claims 14-30, for at least the following reasons.

With exemplary reference to the drawing figures, new independent claim 14 sets forth a speaker arrangement comprising: a speaker 1 including a speaker diaphragm 6, and a speaker frame arrangement (7 or 7 plus 100) fixed to the speaker diaphragm 6 about an outer periphery thereof so that the speaker diaphragm 6 spans across an opening in the speaker frame arrangement, a fixing portion 4 of the diaphragm 6 being defined by a boundary at which the diaphragm 6 meets a periphery of the opening of the frame arrangement; and a speaker grille 3 supported by the speaker frame arrangement 7, 100, the speaker grille 3 having a sound opening 2 therein; wherein the speaker diaphragm 6 includes a diaphragm center (see, for example, Figs. 1A and 1B) and a diaphragm edge portion 4A and is fixed to the speaker frame arrangement 7, 100 in such a manner as to define a diaphragm vibration plane having a shape that is one of circular and oval; wherein the speaker grille 3 includes a blocking portion 5 including a center blocking portion arranged so as to oppose the diaphragm center of the diaphragm 6; wherein the sound opening includes an opening portion that is disposed so as to oppose a region of the diaphragm 6 between the fixing portion 4 and the diaphragm edge portion 4A thereof; and wherein an effective open area provided by the sound opening 2 of the speaker grille 3 is at least 31% and less than 60% of an area of the diaphragm 6.

Claim 21 is similar to claim 14, except that instead of requiring the diaphragm vibration plane to have a shape that is one of circular and oval, specifies that the diaphragm vibration plane has a shape that is oblong and rounded. Also, instead of reciting an effective open area of at least 31% and less than 60% as in claim 14, claim 21 specifies that the effective open area provided by

the sound opening of the speaker grille is at least 22% and less than 60% of an area of the diaphragm 6.

Claim 23 is similar to claim 21 except that it does not specify the effective open area provided by the sound opening and, instead, specifies that the blocking portion 5 includes ribs separating the sound openings 2 and extending in the direction of the minor axis of the vibration plane (see, for example, Figs. 13, 21 and 22).

Independent claim 28 is similar to claim 23 except that, instead of requiring the blocking portion to include ribs separating the sound openings and extending in the direction of the minor axis of the vibration plane as in claim 23, claim 28 specifies that the center blocking portion of the blocking portion 5 constitutes a first rib extending in the direction of the major axis of the vibration plane so as to separate the two sound openings in a direction of the minor axis of the vibration plane (see, for example, Figs. 13 and 20-22).

In contrast to the present invention as recited in the new independent claims 14, 21, 23 and 28, the Grasso patent, which is directed to an ornamental sculpture for a sound emitting device and the manner of fixing such ornamental sculpture to the device, does not disclose the center blocking portion arranged so as to oppose the diaphragm center of the diaphragm, as required by each of the independent claims. In this regard, the Examiner's attention is directed to Figs. 7 and 8 of the Grasso patent, which clearly show a slot formed across the center of the grille, such that the grille does not include a center blocking portion that opposes the diaphragm center of the diaphragm, as required by each of the independent claims. Also, the Grasso patent does not specifically disclose a speaker frame and diaphragm arrangement and, accordingly, cannot be said to disclose or suggest that the sound opening of the grille includes an opening portion that is disposed so as to oppose a region of the diaphragm between the fixing portion and the diaphragm edge portion thereof, as specifically recited in each of the independent claims 14, 21, 23 and 28.

The Grasso patent also fails to disclose or suggest a diaphragm vibration plane that is rounded and oblong, as required by each of the independent claims 21, 23 and 28, and also fails

to disclose or suggest a specific open rate provided by the sound openings, as required by each of claims 14 and 21.

The Moner, Jr. et al. patent was cited by the Examiner for disclosing "that the open area of the sound opening should be in the range of 40 - 50% (column 2, lines 35-38)." However, the Moner, Jr. et al. patent discloses a completely different type of grille arrangement than that disclosed by Grasso. In the present invention as recited in the independent claims 14, 21, 23 and 28, and also in the Grasso patent, there are specific blocking portions of the grille. In contrast, the Moner patent appears to have a mesh-type grille "formed of sheet metal material which has been pierced as by being perforated by or expanded by punching or forming operation to form a pattern of openings extending completely across the area of the cover grille 12" (column 2, lines 27-31). Additionally, the Moner, Jr. et al. patent does not disclose or suggest a circular or oval diaphragm vibration plane, as required by claim 14, nor a rounded and oblong diaphragm vibration plane, as required by claims 21, 23 and 28.

Furthermore, the Moner, Jr. et al. patent does not disclose a specific arrangement of a diaphragm and a frame and, accordingly, cannot be said to disclose or suggest the provision of a sound opening including an opening portion that is disposed so as to oppose a region of the diaphragm between the fixing portion and the diaphragm edge portion thereof, as required by each of the independent claims 14, 21, 23 and 28.

In the Office Action, the Koike patent was applied against claims requiring the diaphragm vibration plane to have an oblong round shape. However, contrary to the Examiner's assertion, there is no disclosure or suggestion in the Koike patent of a diaphragm vibration plane that is rounded and oblong, as required by each of the independent claims 21, 23 and 28. The Examiner pointed to Figs. 1 and 2, but it is noted that Fig. 1 is a perspective view, not a plan view and, accordingly, does not disclose or suggest a rounded, oblong shape.

Furthermore, the Koike patent provides no specific disclosure of the arrangement of the diaphragm, the frame and the grille and, accordingly, cannot be said to disclose or suggest the provision of a sound opening including an opening portion that is disposed so as to oppose a region of the diaphragm between the fixing portion and the diaphragm edge portion thereof, as

required by each of claims 14, 21, 23 and 28. Furthermore, the Koike patent provides no disclosure or suggestion of a particular effective open area provided by the sound opening, as required by each of the independent claims 14 and 21.

Thus, for the above reasons, it is believed apparent that none of the new independent claims 14, 21, 23 and 28 is anticipated by any of Grasso, Koike and Moner, Jr. et al. patents. Furthermore, for the above reasons, it is believed apparent that these references, whether taken individually or in combination, provide no disclosure or suggestion that would have motivated a person of ordinary skill in the art to modify the Grasso arrangement or the Koike arrangement in such a manner as to result in or otherwise render obvious the present invention as recited in each of claims 14, 21, 23 and 28. Therefore, it is respectfully submitted that each of these independent claims, as well as the claims depending therefrom, are clearly allowable over the prior art of record.

In view of the foregoing amendments and remarks, it is respectfully submitted that the present application is clearly in condition for allowance. An early notice thereof is earnestly solicited.

If, after reviewing this Amendment, the Examiner feels there are any issues remaining which must be resolved before the application can be passed to issue, it is respectfully requested that the Examiner contact the undersigned by telephone in order to resolve such issues.

Respectfully submitted,

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## DESCRIPTION

### SPEAKER GRILLE

5 This application is a U.S. national phase application of PCT international application PCT/JP2004/011632.

#### TECHNICAL FIELD

The present invention relates to a speaker grille attached to a cabinet, etc. for  
10 combination with a speaker.

#### BACKGROUND ART

A speaker grille is designed so that it has a sufficient mechanical strength needed for protecting a speaker from damage, and at the same time it has to provide a speaker with  
15 an opening that is large enough not to ill-affect the quality of reproduced sounds. For those speakers whose diaphragm areas are small, among other speaker types, new structures have been proposed for their speaker grilles in order to ~~reduce an~~ minimize the area ~~which blocks of the~~ diaphragm region to a minimum that is blocked, while securing a sufficient mechanical strength. Japanese Patent Unexamined Publication No. 2003-37883  
20 discloses a conventional speaker grille 91 as shown in FIG. 27; which speaker grille is disposed in front of speaker 92, and provided with sound openings 93 whose open rates are uneven.

Speaker grilles require quite a high open rate ~~for not to~~ to avoid retarding sound vibration of the speakers. The main sound openings are disposed in an area corresponding  
25 to the central region of a diaphragm, where the sound pressure level is high. Describing more practically, the ~~sum total~~ area of sound openings has to be at least 60%, if the characteristics ~~have are~~ to be kept within approximately -6 dB for the sounds of 5 kHz and

higher. The smaller the speaker size is, the higher the open rate that is required for the speaker grille.

FIG. 28 is a sound characteristics chart of a speaker combined with a speaker grille whose open rate is as low as 28 %. In the chart, the solid line represents sound characteristics 95 with no speaker grille attached, while the dotted line represents sound characteristics 96 with the speaker grille attached. The sound pressure level is lower in the vicinity of 5 kHz and of 10 kHz with sound characteristics 96 shown in dotted line, as compared with characteristics 95. On the other hand, sound characteristics 96 exhibit a higher sound pressure level in the vicinity of 3 kHz; which is due to resonance. Thus, 10 design in the sound openings of a speaker grille gives significant influence to significantly influences the sound characteristics of sounds of a speaker combined with the speaker grille.

The intrinsic task of a speaker grille is to protect a speaker from damage, so it has to have a certain mechanical strength. Therefore, there is a limitation to making the open 15 rate of the sound opening openings larger. The speaker grille as shown in FIG. 27 secures a certain open rate by providing rectangular sound openings in the area opposing to the diaphragm edge, in addition to the area opposing to the central part of the diaphragm. This configuration, however, requires a certain thickness for ensuring a required mechanical strength. This means that it is not suitable for use with the small-size speakers, 20 among other types of speakers.

#### DISCLOSURE OF INVENTION

A speaker grille in the present invention is disposed in front of a diaphragm speaker which reproduces the sounds of 1 kHz and higher. The speaker grille is provided 25 with a sound opening which includes a line-sound opening portion which opposes to a region from the edge portion of a speaker diaphragm to the fixing portion on the outer circumference of the diaphragm. The speaker grille provides superior sound

characteristics, at the same time as well as sufficient mechanical strength either.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a perspective view showing a speaker grille in accordance with a first exemplary embodiment of the present invention, and a speaker connected with the speaker grille.

FIG. 1B is a cross sectional view showing a key part of the speaker shown in FIG. 1A.

FIG. 1C is a cross sectional view showing a key part of another speaker coupled with the speaker grille of FIG. 1A.

FIG. 2 shows sound characteristics exhibited by a combination of the speaker grille and the speaker of FIG. 1A.

FIG. 3 shows sound characteristics exhibited by a combination of a speaker grille having a sound opening at the center and the speaker of FIG. 1A.

FIG. 4 shows sound characteristics exhibited by the speaker of FIG. 1A which is when half blocked to be half in along the direction of the major axis.

FIG. 5 shows sound characteristics exhibited by the speaker of FIG. 1A which is when half blocked to be half in along the direction of the minor axis.

FIG. 6 shows sound characteristics exhibited by a combination of the speaker grille and the speaker of FIG. 1A.

FIGs. 7 through 9 show sound characteristics exhibited by the speaker grille of FIG. 1A, with different open rates.

FIG. 10 is a perspective view showing a speaker grille in accordance with a second exemplary embodiment of the present invention and a speaker connected with the speaker grille.

FIG. 11 shows sound characteristics exhibited by a combination of the speaker grille and the speaker of FIG. 10.

FIG. 12 shows sound characteristics exhibited by a combination of a speaker grille having a sound opening at the center and the speaker of FIG. 10.

FIG. 13 is a perspective view showing a speaker grille in accordance with a third exemplary embodiment of the present invention and a speaker connected with the speaker grille.

FIG. 14 shows sound characteristics of the speaker of FIG. 13 ~~which is when half blocked to be half in along~~ the direction of the major axis.

FIG. 15 shows sound characteristics of the speaker of FIG. 13 ~~which is when half blocked to be half in along~~ the direction of the minor axis.

FIG. 16 shows sound characteristics exhibited by a combination of the speaker grille and the speaker of FIG. 13.

FIGs. 17 through 19 show sound characteristics exhibited by the speaker grille of FIG. 13 with different open rates.

FIGs. 20 through 22 show the structures of other speaker grilles in the third embodiment of the present invention.

FIG. 23 shows sound characteristics exhibited by a combination of the speaker grille in FIG. 20 and the speaker in FIG. 13.

FIG. 24 shows sound characteristics exhibited by a combination of the speaker grille in FIG. 21 and the speaker in FIG. 13.

FIG. 25 shows sound characteristics exhibited by a combination of the speaker grille in FIG. 22 and the speaker in FIG. 13.

FIG. 26 is a cross sectional view showing a state of an exemplary combination where the speaker in FIG. 13 is connected with either one of the speaker grilles in FIGs. 20 through 22.

FIG. 27 shows a structure of a conventional speaker grille.

FIG. 28 shows sound characteristics exhibited by a conventional configuration in which the open area is reduced.

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Exemplary embodiments of the present invention are described in the following with reference to the drawings. In each of the following embodiments, those portions 5 having the identical structures as those of preceding embodiments are represented by using the identical symbols, and detailed description ~~on-of such portion-portion~~ is sometimes eliminated. It is to be noted that the descriptions of embodiments are just exemplary; they should not be interpreted to limit the scope of the invention.

## FIRST EXEMPLARY EMBODIMENT

10 FIG. 1A is a perspective view showing a speaker grille in accordance with a first exemplary embodiment of the present invention and a speaker connected with the speaker grille. FIG. 1B is a cross sectional view of the speaker shown in FIG. 1A. Speaker 1 is provided with diaphragm 6 which forms an oval vibration plane with the major axis of 12 cm and the minor axis of 8 cm. Diaphragm 6 is fixed at the outer circumference to frame 15 7 and gasket 100. Speaker grille 3 is disposed in front of speaker 1, and fixed to frame 7 which covers diaphragm 6. Speaker grille 3 may be made of an acrylic resin or the like resin, aluminum or other metal material, using a cutting process or a die-molding process. Speaker grille 3 has a thickness of about 0.1 – 10 mm. Speaker grille 3 may be formed as an integral part of a cabinet for a television receiver, radio receiver or the like audio 20 apparatus; there is no specific limitation to the material used, it may be provided by cutting a wooden material, for example.

Speaker grille 3 is provided with sound openings 2, which is ~~divided~~ are separated by reinforcement ~~rib-rib~~ 5 disposed for ensuring a certain mechanical strength over the entire speaker grille 3. Each of sound openings 2 includes ~~line-8-a~~ a sound opening portion 25 that is ~~opposing~~ opposed to a region ~~from-of~~ between edge portion 4A of diaphragm 6 ~~to-and~~ fixing portion 4 on the outer circumference of diaphragm 6. Each sound opening 2 has arc-curved boundary portion 9 that is in parallel with fixing portion 4

on the outer circumference of diaphragm 6. By forming sound openings 2 in the above-described manner so that they include arc-curved boundary portions 9 proceeding along fixing portion 4 on the outer circumference, sound openings 2 are provided so that it contains as to contain, to the maximum extent, the area opposing to-edge portion 4A of diaphragm 6. In the example shown in FIG. 1A, outer curved boundary portion 9 is shown in coincidence with fixing portion 4; ~~so, the line opposing to a region from edge portion 4A to fixing portion 4 on the outer circumference of diaphragm 6 can be explicitly recognized as line 8. However, the perforated area of sound opening 2 may include such line which we sometimes fail to explicitly recognize.~~

10 Here, the terminology "fixing portion 4 on the outer circumference of diaphragm 6" signifies the inner ~~circumference line~~ circumferential edge of gasket 100, the gasket being provided at the outer circumference of edge portion 4A. In a case where the speaker is not provided with a gasket as shown in FIG. 1C, the terminology indicates the inner circumferential ~~line~~ edge of frame 7 ~~locating~~ located at the outside of edge portion 4A.

15 The frame with or without the gasket can be called a frame arrangement. In any case, fixing portion 4 signifies the outermost circumference of a vibration plane which vibrates when speaker 1 generates ~~sounds~~ sound. However, since the main vibration part is at a place ~~inner than~~ inwardly of the outer circumference of edge portion 4A, it is preferred that sound opening 2 include a line ~~sound opening portion~~ that opposes to outer circumference

20 4B of edge portion 4A.

Sound characteristics exhibited by a combination of the above-configured speaker grille 3 and speaker 1 are shown in FIG. 2. Meanwhile, sound characteristics exhibited by a combination of a speaker grille having a round opening of the same ~~square measure total area~~ as that of sum of sound openings 2 at the center to be concentric with diaphragm 6 and speaker 1 are shown in FIG. 3. In either of the above combinations, there is no serious difference between characteristics curve 11 representing the sounds without a speaker grille and characteristics curves 12, 13 representing the sounds with the speaker grilles attached,

in so far as the sound region lower than 1 kHz is concerned. Characteristics curve 13, however, shows resonance in the vicinity of 1 – 2 kHz and in the vicinity of 4 kHz, and, as a reaction to it, the harmonic characteristics deteriorate. On the other hand, characteristics curve 12 indicates a significant improvement with respect to the characteristics 5 deterioration. These teach us that even if ~~sum of the square measure total area~~ of the sound openings is equal, the speaker grille generates resonance when the area opposing to edge portion 4A is blocked; furthermore, the characteristics deteriorate in the high sound region of 9 kHz or higher. Therefore, it is preferred that a speaker grille be designed ~~into~~ such to have a structure as shown in FIG. 1A. Thus, speaker grille 3 brings about an 10 advantage for those speakers which reproduce the sounds of 1 kHz and higher.

Next, the sound characteristics are compared using speaker grilles each having a 50 % open rate; between a combination with speaker 1 when half blocked to be half in along the direction of the major axis and speaker 1 when half blocked to be half in along the direction of the minor axis. The respective sound characteristics are shown with 15 characteristics curve 14 in FIG. 4 and characteristics curve 15 in FIG. 5. Here, the terminology “open rate” stands for a proportion of effective open area provided by sound openings 2 against a projected area of diaphragm 6. In a case where part of sound openings 2 coincide with fixing portion 4, as shown in FIG. 1A, or a case where sound openings 2 are disposed to be inner than inwardly of fixing portion 4, the effective open 20 area is ~~sum of the square measure areas~~ of sound openings 2 itself. On the other hand, in a case where any of sound openings 2 include the portion that is opposing opposed to fixing portion 4, the effective open area is the sum of the area areas of sound openings 2 minus a ~~square measure total area~~ blocked by gasket 100 or frame 7.

The sound characteristics exhibited by a combination of speaker grille 3 having 25 the same open rate as described above in the same pattern as shown in FIG. 1A and speaker 1 are shown with characteristics curve 16 in FIG. 6. Both FIG. 4 and FIG. 5 exhibit resonance; this is because, as already described earlier, a substantial part of an area

opposing to-edge portion 4A is blocked. On the other hand, characteristics curve 16 exhibits superior characteristics with the resonance suppressed, as compared with characteristics curves 14 and 15.

Now in the following, description is made ~~on-of~~ of the change of sound characteristics caused as the result of ~~varied various open-rate rates~~, which ~~variation in the open rate is-rates are~~ devised by changing width 2A of sound openings 2. Characteristics curve 17 in FIG. 7 represents the sound characteristics when width 2A is 5 mm, whereas characteristics curve 18 in FIG. 8 represents those when width 2A is 10 mm. The greater the width 2A is, the better the sound characteristics are. Characteristics curve 19 in FIG. 9 which represents an example where width 2A is 15 mm is substantially identical to curve 16 in FIG. 6; deterioration in the characteristics is suppressed to be approximately -3 dB in the sound region of 1 kHz or higher. The open rate of the example is 31 %. Namely, the open rate should preferably be at least 31 %. From the view point of mechanical strength of speaker grille 3, the open rate should preferably be lower than 60 %.

## 15 SECOND EXEMPLARY EMBODIMENT

FIG. 10 is a perspective view showing a speaker grille in accordance with a second exemplary embodiment of the present invention and a speaker connected with the speaker grille. Speaker 1 is provided with diaphragm 6 which forms a round vibration plane of 8 cm diameter. The ~~rest remaining~~ parts of the structure ~~remains are~~ the same as those in the first embodiment.

Sound characteristics exhibited by a combination of the above-configured speaker grille 3 and speaker 1 are shown in FIG. 11. Meanwhile, FIG. 12 shows sound characteristics exhibited by a combination of a speaker grille which is provided with, instead of sound openings 2, a round opening of the same ~~square measure as sum of total area as~~ sound openings 2 disposed to be concentric with the center of diaphragm 6, and speaker 1. In either of the above combinations, there is no serious difference between characteristics curve 20 representing the sounds without a speaker grille and characteristics

curves 21, 22 representing the sounds with the speaker grilles attached, in so far as the sound region lower than 1 kHz is concerned. Characteristics curve 22, however, shows resonance in the vicinity of 1 – 2 kHz and in the vicinity of 5 kHz; and, as a reaction to it, the harmonic characteristics deteriorate. On the other hand, characteristics curve 21 5 indicates a significant improvement with respect to the characteristics deterioration. Thus, even if ~~sum of the square measure~~ the total area of the sound openings is equal, the speaker grille generates resonance and results in a substantial deviation from a speaker's own sound characteristics when the area opposing to-edge portion 4A is blocked. Therefore, it is preferred that the speaker grille be designed ~~into such to have~~ a structure as shown in FIG 10 10. Preferred The preferred open rate in the present embodiment is at least 31% and lower than 60 %, which ~~being~~ is the same as that described in the first embodiment. Detailed description on which is eliminated here.

### THIRD EXEMPLARY EMBODIMENT

FIG. 13 is a perspective view showing a speaker grille in accordance with a third 15 exemplary embodiment of the present invention and a speaker connected with the speaker grille. Speaker 1 measures 73 mm ~~in on~~ the longer side and 17 mm ~~in on~~ the shorter side, ~~which and~~ is provided with diaphragm 6 ~~of having an~~ oblong vibration plane. Diaphragm 6, made of a polyimide or the like resin film, is fixed at the circumference with frame 7. Speaker grille 3 is disposed in front of speaker 1, and fixed to frame 7 covering diaphragm 20 6.

Speaker grille 3 is provided with sound openings 2, which are ~~divided~~ separated by reinforcement ribs 5 and block portion 5A; reinforcement ribs 5 are disposed for ensuring a certain mechanical strength over the whole speaker grille 3, and block portion 5A blocks the central region of the vibration plane. Block portion 5A protects the central 25 area of diaphragm 6. Each of sound openings 2 includes ~~line 8~~ a sound opening portion that ~~is opposing to~~ opposes a region ~~from~~ of diaphragm 6 between edge portion 4A ~~of~~ diaphragm 6 ~~to~~ and fixing portion 4 ~~on~~ at the outer circumference of diaphragm 6. Sound

openings 2 at both ends of grille 3 have arc-curved portion-boundary portions 9 which are disposed in parallel with fixing portion 4 on the outer circumference of diaphragm 6. By forming sound openings 2 in-with the above layout where it includes-including curved portion-boundary portions 9 along fixing portion 4 at the outer circumference of diaphragm 6, sound openings 2 can be provided to contain, to the maximum extent, the area opposing to-edge portion 4A.

Sound characteristics exhibited by a combination of the above-configured speaker grille 3 and speaker 1 are shown with characteristics curve 26 in FIG 16. The open rate against the cross sectional area of vibration plane is 47 %, in the present case. Meanwhile, sound characteristics exhibited by a combination with a speaker grille of the same open rate blocking half of speaker 1 in the direction of the longer side are shown with characteristics curve 24 in FIG. 14, and those with a speaker grille blocking half of speaker 1 in the direction of the shorter side are shown with characteristics curve 25 in FIG. 15. In either of the above charts, characteristics curve 23 represents those without speaker grille 3.

Characteristics curve 24 shows resonance. This is due to the large blocking area opposing edge portion 4A. On the other hand, the resonance is suppressed in characteristics curves 25 and 26. The reason why the resonance is suppressed in curve 25 seems to be in-due to the fact that the size of speaker 1 in the present embodiment is smaller than the counterparts in the first and the second embodiments. In the sound region of 5 kHz – 10 kHz, however, curve 26 exhibits a profile which is closer to curve 23 than that of curve 25; which means curve 26 is more favorable.

Next, change changes in the sound characteristics caused by varied-varying the open rate, devised- by changing widths 2A, is described. Characteristics curve 27 in FIG 17 exhibits the sound characteristics when width 2A is 2 mm, whereas characteristics curve 28 in FIG. 18 exhibits those when width 2A is 3 mm. As can be understood from the charts, the sound characteristics improve along with the increasing width 2A. Characteristics curve 26 in FIG. 16 represents the result where width 2A is 4 mm; the curve

is substantially identical to curve 29 in FIG. 19, which represents the result where width 2A is 5 mm. In the above two curves, deterioration of the characteristics is suppressed to be approximately -3 dB in the sound region of 1 kHz or higher. The open rate in this case is 47 %, as already described earlier. Namely, the open rate is preferably at least 47 %.

5 Whereas from the view point of ensuring a certain mechanical strength with speaker grille 3, the open rate is preferably lower than 60 %.

Now in the following, description is made on-of variations in the shape of speaker grille 3 connected to the so-called slim-type speaker 1 of FIG. 13. FIG. 20 shows a variation of speaker grille 3; sound openings 2 are provided only in the area corresponding 10 to edge portion 4A, reinforcement rib 5B is provided in parallel with the longer sides of the vibration plane and is located at the center in the direction of the shorter sides of the vibration plane, so that it separates two sound openings 2 in the direction of the shorter sides of the vibration plane. Namely, one reinforcement rib 5B is formed laterally with an approximate width of 6 mm expanding equally in the upward and downward directions 15 from the central laterally extending center line towards up and down.

FIG. 21 and FIG. 22, respectively, show other exemplary variations of speaker grille 3; they are provided with a plurality of reinforcement ribs 5 disposed in parallel with the shorter sides of the vibration plane for further splitting the two sound openings, further 20 to the configuration shown in FIG. 20. Namely, rib 5B is formed laterally with an approximate width of 6 mm expanding equally in the upward and downward directions from the central laterally extending center line towards up and down. In addition, sound 25 openings 2 having an approximate width of 14 mm and ribs 5 having an approximate width of 2 mm are alternately disposed in along the right-left direction with equal orientation from the central center line for as long as approximately 50 mm in the lateral length length, and the sets of the openings and ribs are disposed in a longitudinal direction, in FIG. 21. In FIG. 22, sound openings 2 having an approximate width of 4 mm and ribs 5 having an approximate width of 4 mm are disposed alternately with equal orientation from the central

center line in the lateral direction. The open ~~rate-rates~~ in FIG 20, FIG 21 and FIG 22 are 48 %, 28 % and 22 %, respectively. Sound characteristics of these speaker grilles 3 connected with speaker 1 of FIG 13 are shown in the respective charts shown in FIG 23, FIG. 24 and FIG. 25. In each of the charts, solid line curve 31 represents the 5 characteristics without a speaker grille, while dotted line curves 33, 34 and 35 exhibit those with a speaker ~~net~~ grille.

In the combination corresponding to FIG 23, ~~an~~ open rate of 48 % is secured against the aperture area of the speaker. Therefore, the characteristics curve 33 shows hardly any deviation from the original characteristics curve 31. In the combination 10 corresponding to FIG. 24, the open rate is 28 % against the aperture area of the speaker; therefore, the characteristics are inferior as compared to characteristics curve 33, but the characteristics deterioration is suppressed to be approximately -3 dB in the sound region of 8 kHz or higher. In the combination corresponding to FIG. 25, the open rate is 22 % against the aperture area of the speaker; therefore, the characteristics are inferior compared 15 to characteristics curve 33, but the characteristics deterioration is suppressed to be approximately -6 dB in the sound region 5 kHz or higher.

Furthermore, it is preferred to provide magnet 43 on speaker grille 3 at the surface facing to diaphragm 6, as illustrated in FIG 26, a cross sectional view. Speaker 1 has flat voice coil 42 disposed on diaphragm 6 at the location opposing to magnet 41. Magnet 43 20 can be attached to block portion 5A or rib 5B. Further, yoke 44 may be provided in order to have magnetic flux of magnet 43 more concentrated.

Magnet 43 is disposed to oppose magnet 41 in a repulsive polarity arrangement. With such a configuration, ~~the~~ direction of generated magnetic flux is orientated to be horizontal and the electric current traveling in coil 42 makes a perpendicular crossing with 25 the magnetic flux. This enhances the magnetism efficiency.

Although sound openings 2 in each of the above embodiments are described ~~in a shape that it is as having~~ surrounded with an arc curve or a straight line, it is not the

intension of the present invention to limit the shape of sound opening 2 as such. Sound openings 2 may be provided in whatever manner so far as they are formed ~~in an area within the inside of line 8 and they include line 8; the line is to include a sound opening portion~~ facing the region extending from edge portion 4A of speaker 1 to fixing portion 4 on the 5 outer circumference of diaphragm 6.

Although sound openings 2 in each of the above embodiments are described that ~~they include a line as including a sound opening portion~~ opposing to-fixing portion 4 on the outer circumference, it is not the ~~intension intention~~ of the present invention to limit it as such. For example, sound openings 2 may be provided in such a manner where they 10 include a line which is ~~opposing to opposes~~ the inner circumference of edge portion 4A and are formed to be ~~inner than inward~~ of the line. With this configuration, the advantage of the present invention can be implemented to some extent. Especially with those speakers of large aperture diameter, even a sound opening provided in an area ~~inner than inward~~ of the inner circumference of edge portion 4A can ensure satisfactory sound characteristics. 15 With the speakers of small aperture diameter, however, deterioration in the sound characteristics is significant if there is no sound opening 2 in front of edge portion 4A. So, it is preferred to provide sound opening 2 ~~in a manner so~~ that it includes a line which is facing a virtual line ~~located~~ at least 3 mm ~~inner inwardly~~ from the outer circumference of edge portion 4A. The approximate distance of 3 mm can offer an 20 advantage that is identical to that described in the embodiments of the present invention.

#### INDUSTRIAL APPLICABILITY

A speaker grille of the present invention is disposed in front of a speaker having a diaphragm and reproducing the sounds of 1 kHz or higher. The speaker grille is provided 25 with a sound opening which includes a line opposing to a region extending ~~from between~~ the edge portion of the diaphragm ~~to and~~ the fixing portion on the outer circumference of the diaphragm. The sound opening is provided only in an area ~~inner than inward~~ of the

line. The above-configured speaker grilles offer practical advantages when used as the sound aperture for acoustic apparatus which includes a speaker.

## ABSTRACT

A speaker grille is disposed in front of a speaker having a diaphragm and reproducing the sounds of 1 kHz and higher. The speaker grille is provided with a sound opening which includes a line-sound opening portion that opposes to-a region extending 5 from the edge portion of a diaphragm to the fixing portion on the outer circumference of the diaphragm of the speaker. The speaker grille offers superior sound characteristics, and at the same time a sufficient mechanical strength-either.